

北大低温研・研究集会

干渉計解析の概要

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Interferometer in radio (1D): Each antenna obtains “*E*-field” information

Cross correlation for $\delta\phi$ direction

$$|E(\delta\phi)|^2 \exp\left(+i2\pi\frac{D}{\lambda}\delta\phi\right)$$

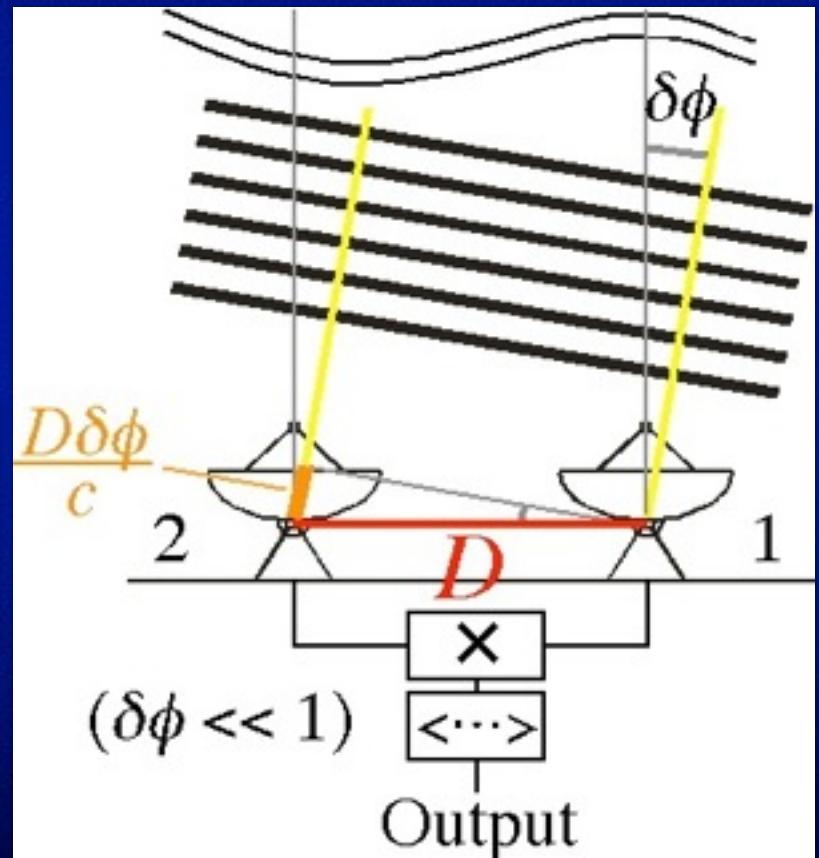
Integrating all the directions

$$V(D) = \int T(\delta\phi) \exp\left(+i2\pi\frac{D}{\lambda}\delta\phi\right) d(\delta\phi)$$

$V(D)$ is a Fourier component of $T(\delta\phi)$

→ Image can be reconstructed by data from many baselines

when the delay is adjusted
to the zenith ...



Visibility and Brightness in 2D

Definition of “uv vector” for a projected baseline

$$\vec{D} = (D_u, D_v) \equiv \lambda(u, v)$$

(u, v) は地面, (x, y) は天球。 $u \parallel x$ は東西, $v \parallel y$ は南北

Fourier Transform between Visibility and Sky Brightness

$$V(u, v) = \iint T(x, y) e^{+i2\pi(ux+vy)} dx dy$$

$$T(x, y) = \iint V(u, v) e^{-i2\pi(ux+vy)} du dv$$

In reality, (1) antenna power pattern and
(2) uv-sampling also affect the obtained data ...

$$(1) \frac{V(u, v)}{\text{(得られる)}} \Leftrightarrow \frac{P(x, y)T(x, y)}{\text{(パワーパターン)}} \text{ (真の輝度分布)}$$

ビジビリティ

※パワーパターンは測定可能な量

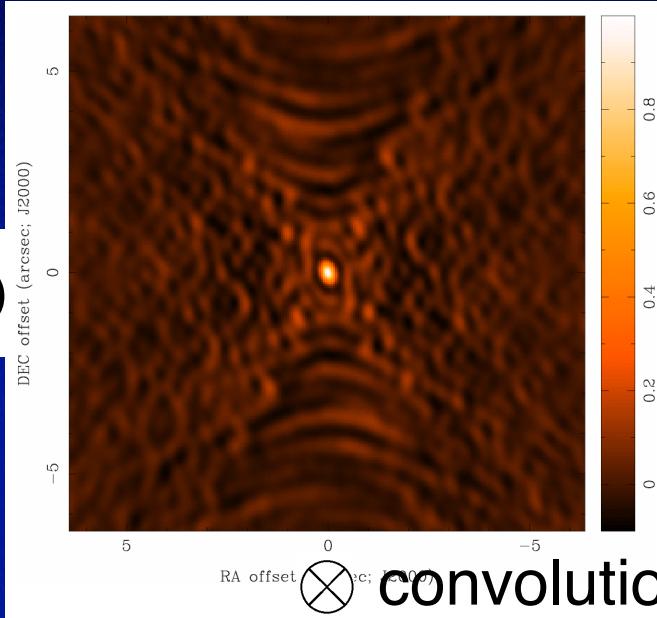
$$(2) \frac{P(x, y)T_{\text{dirty}}(x, y)}{\text{ (標本関数 or 重み関数)}} \text{ (直接出るマップ= Dirty Map)}$$
$$= \iint [S(u, v)V(u, v)] e^{-i2\pi(ux+vy)} dudv$$
$$= \frac{B(x, y) * [P(x, y)T(x, y)]}{\text{ (Dirty Beam)}} \text{ (求めたい輝度分布)}$$

where $S(u, v) \Leftrightarrow B(x, y)$

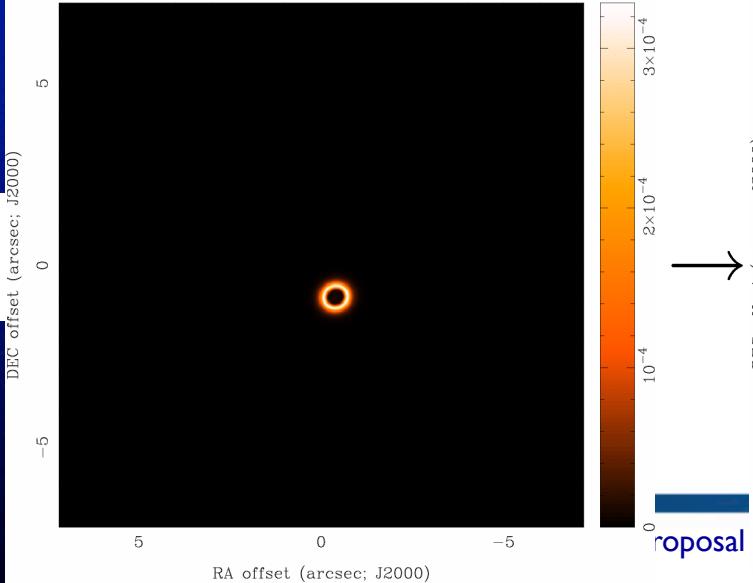
※関数積のフーリエ変換 = 各関数のフーリエ変換の畳み込み

Visibility vs. Image (from NAASC Memo #104)

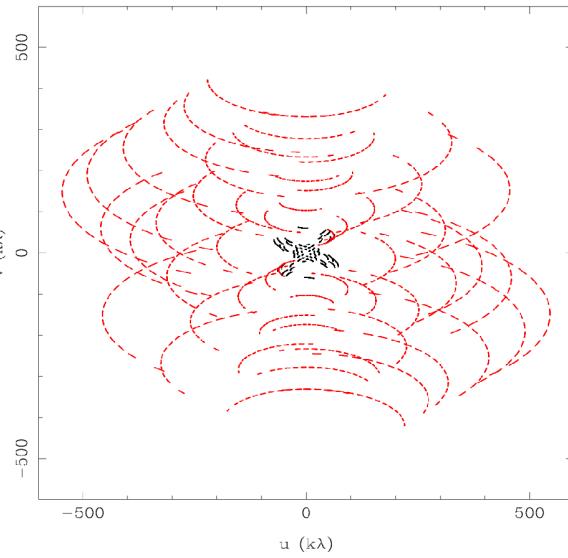
$B(x,y)$



$T(x,y)$

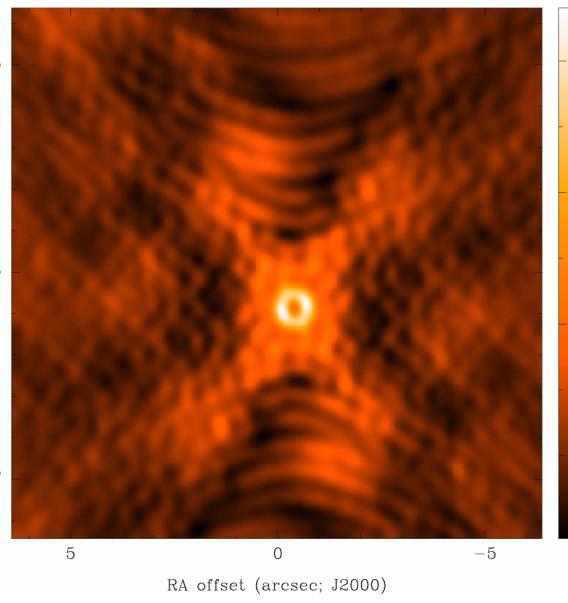


1 ↴



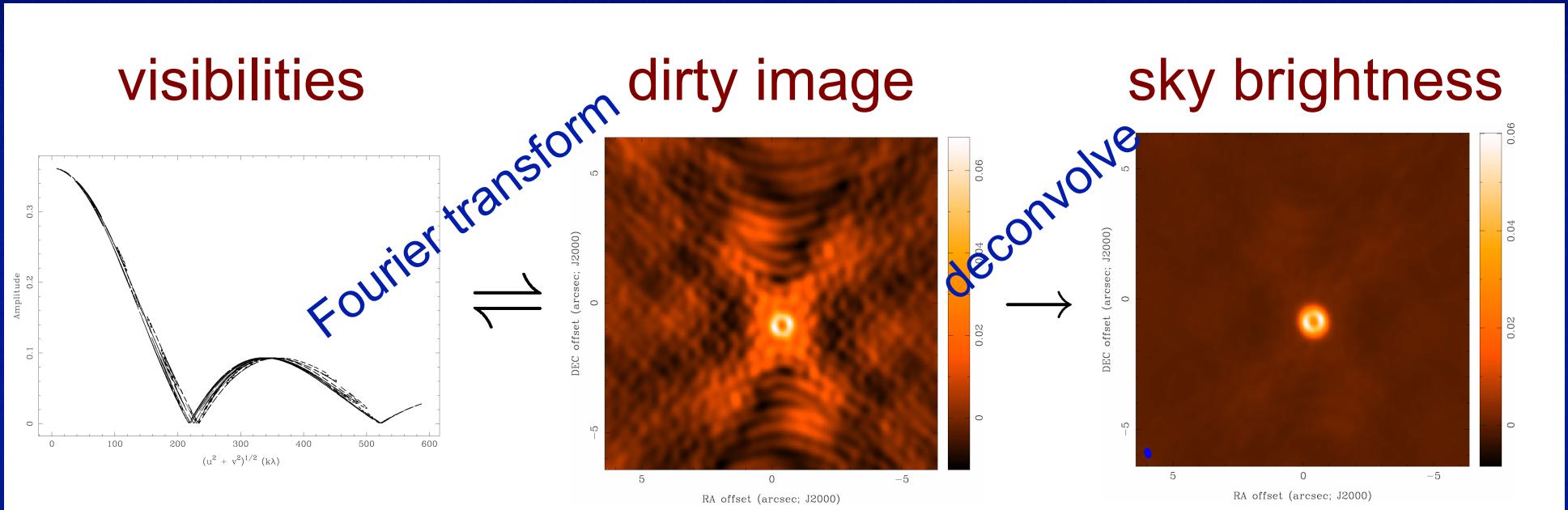
$S(u,v)$

↓



Dirty
Image

Visibility → Dirty Image → Deconvolved Image (from NAASC Memo #104)

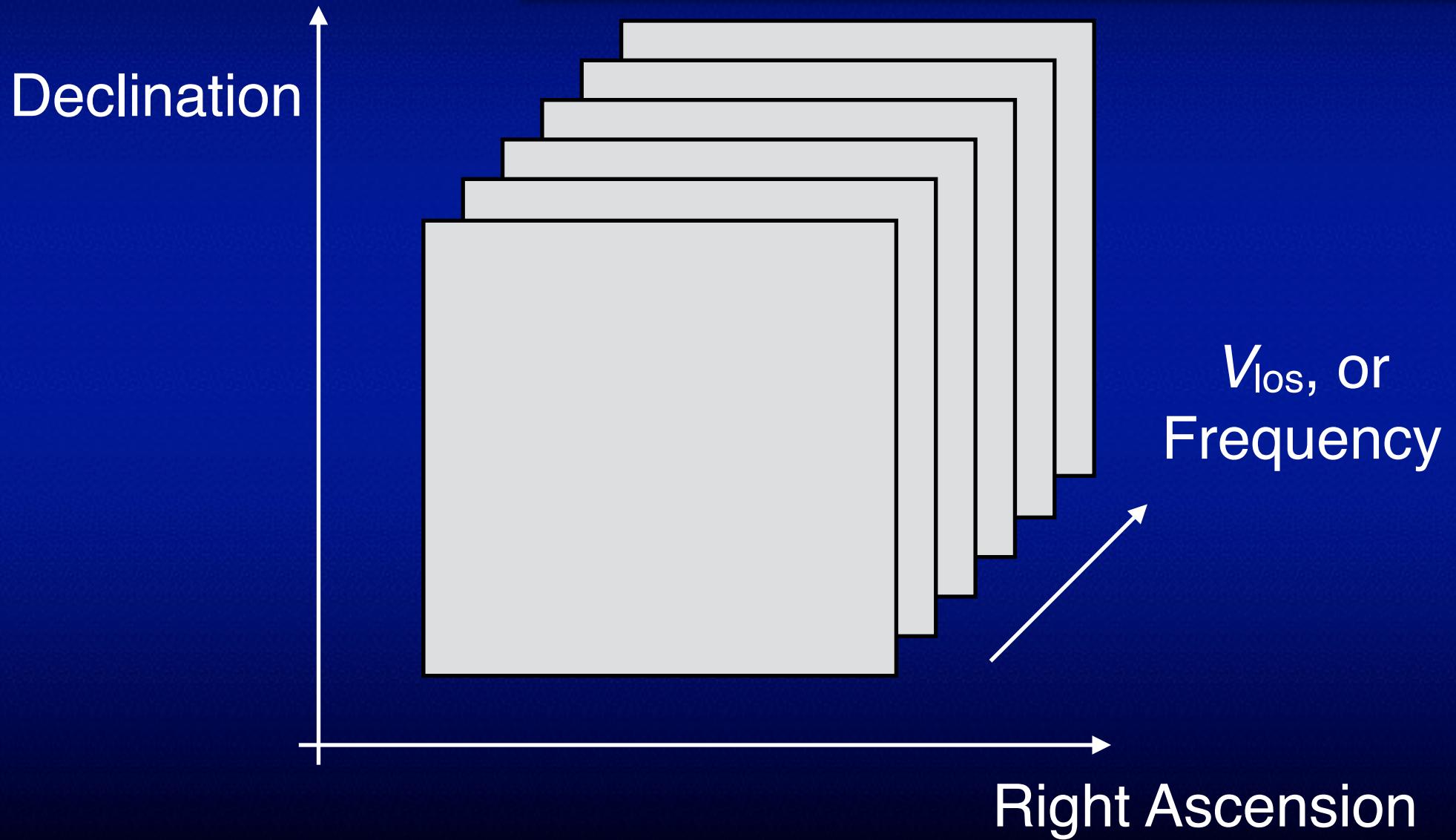


Deconvolution Method
CLEAN
MEM

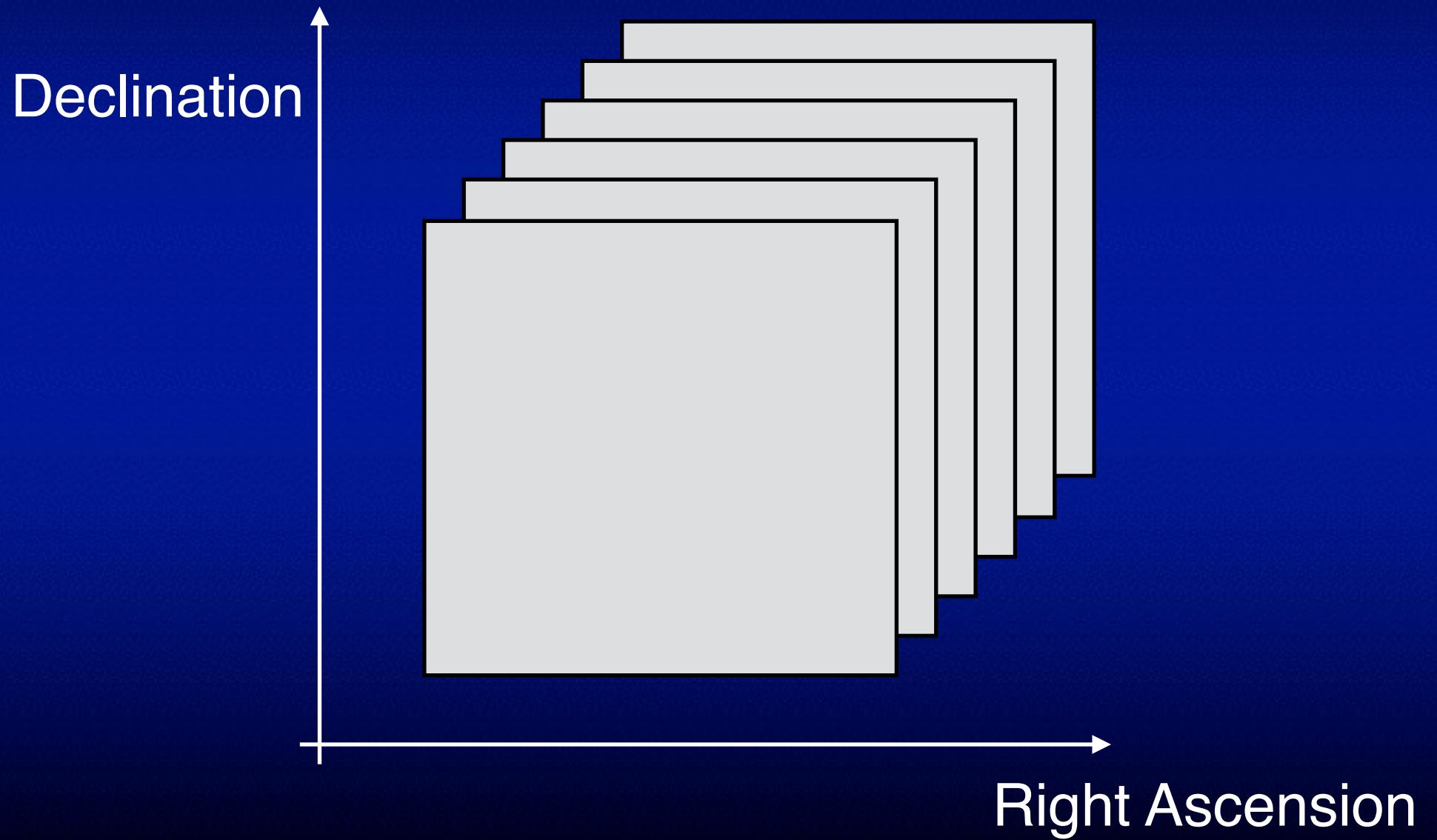
Data Cube

$T(x, y, \nu)$, or $T(\alpha, \delta, v_{\text{los}})$

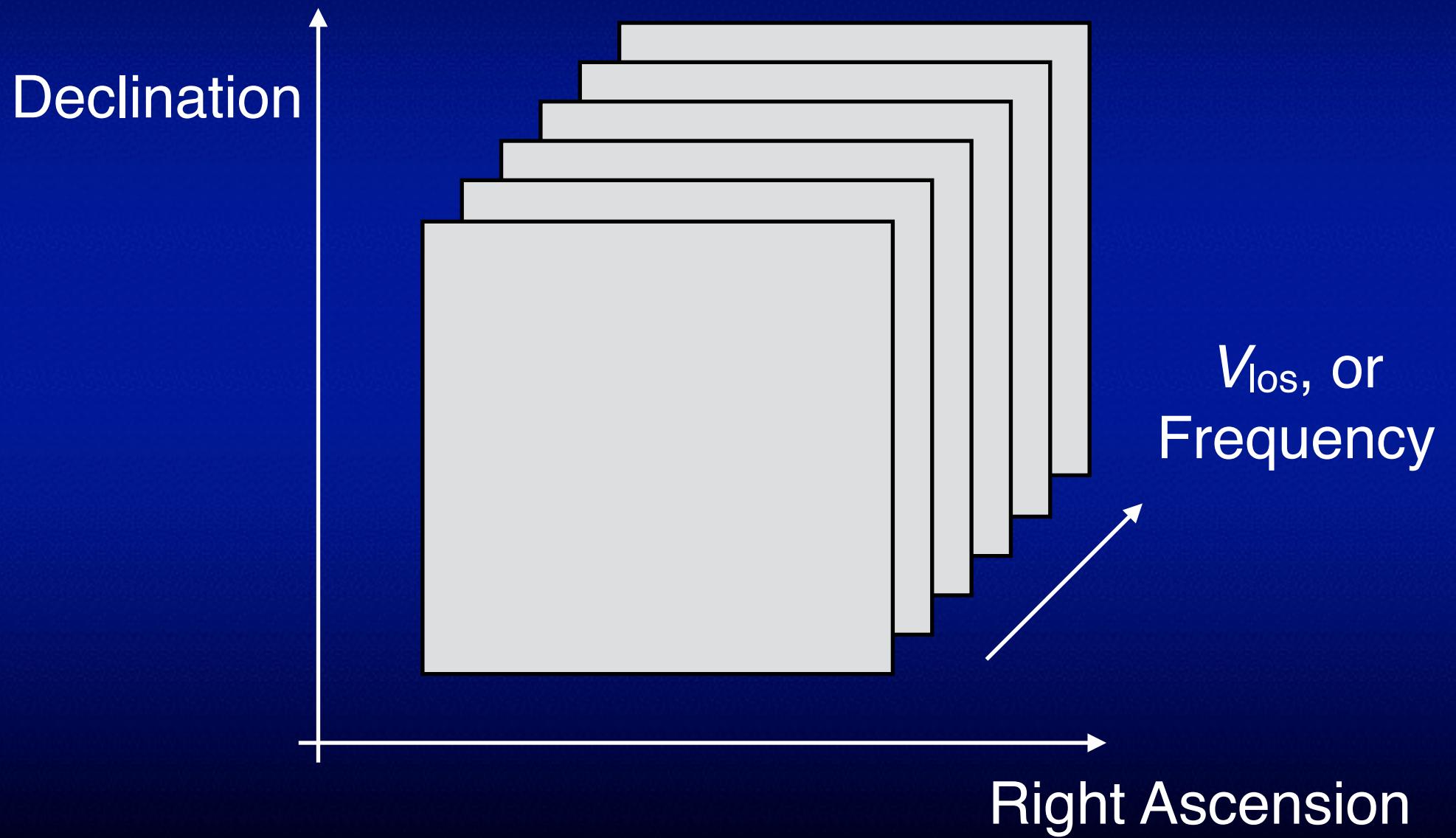
v_{los} is measured in “Local Standard of Rest” (LSR).



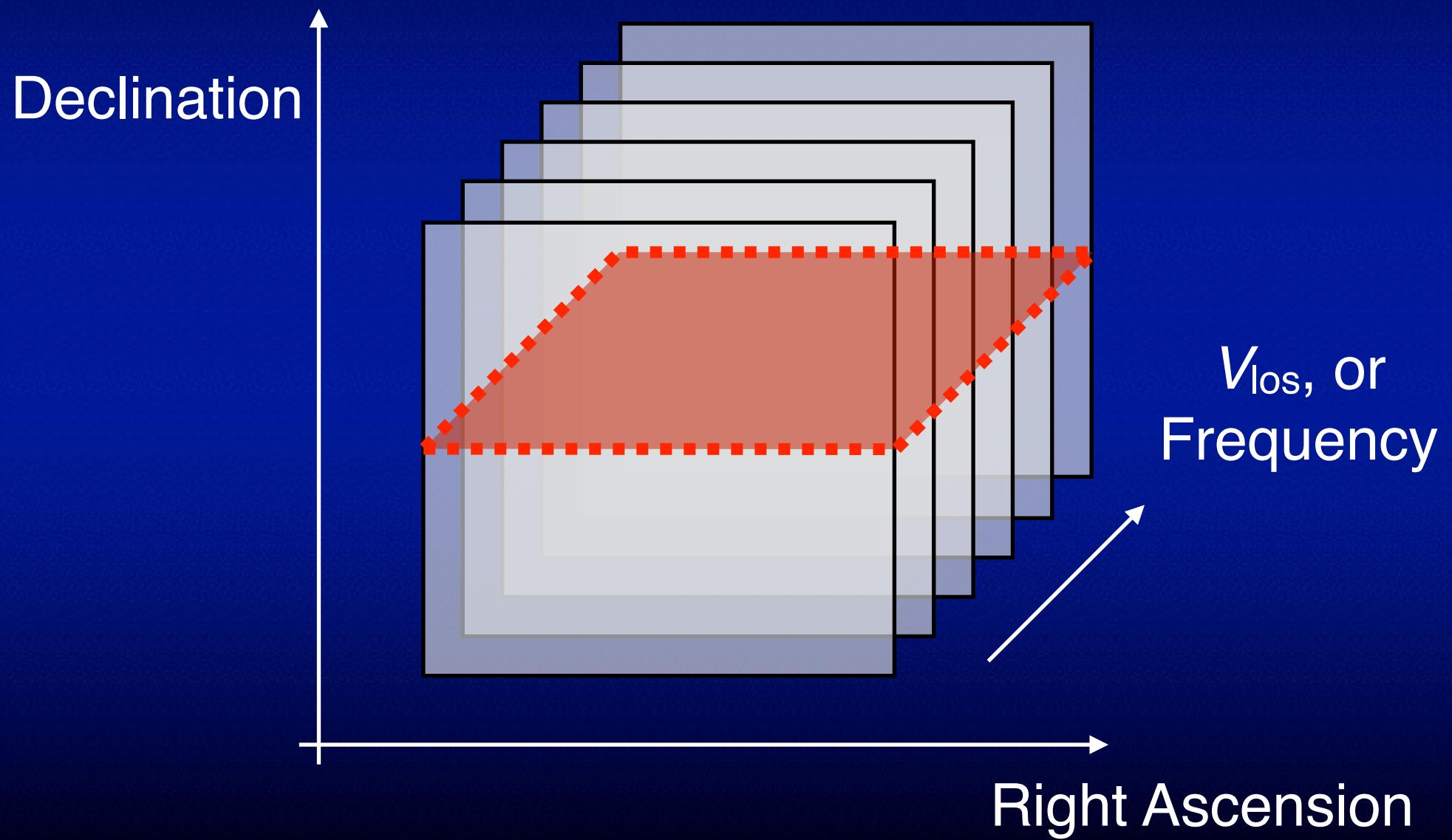
Channel Maps



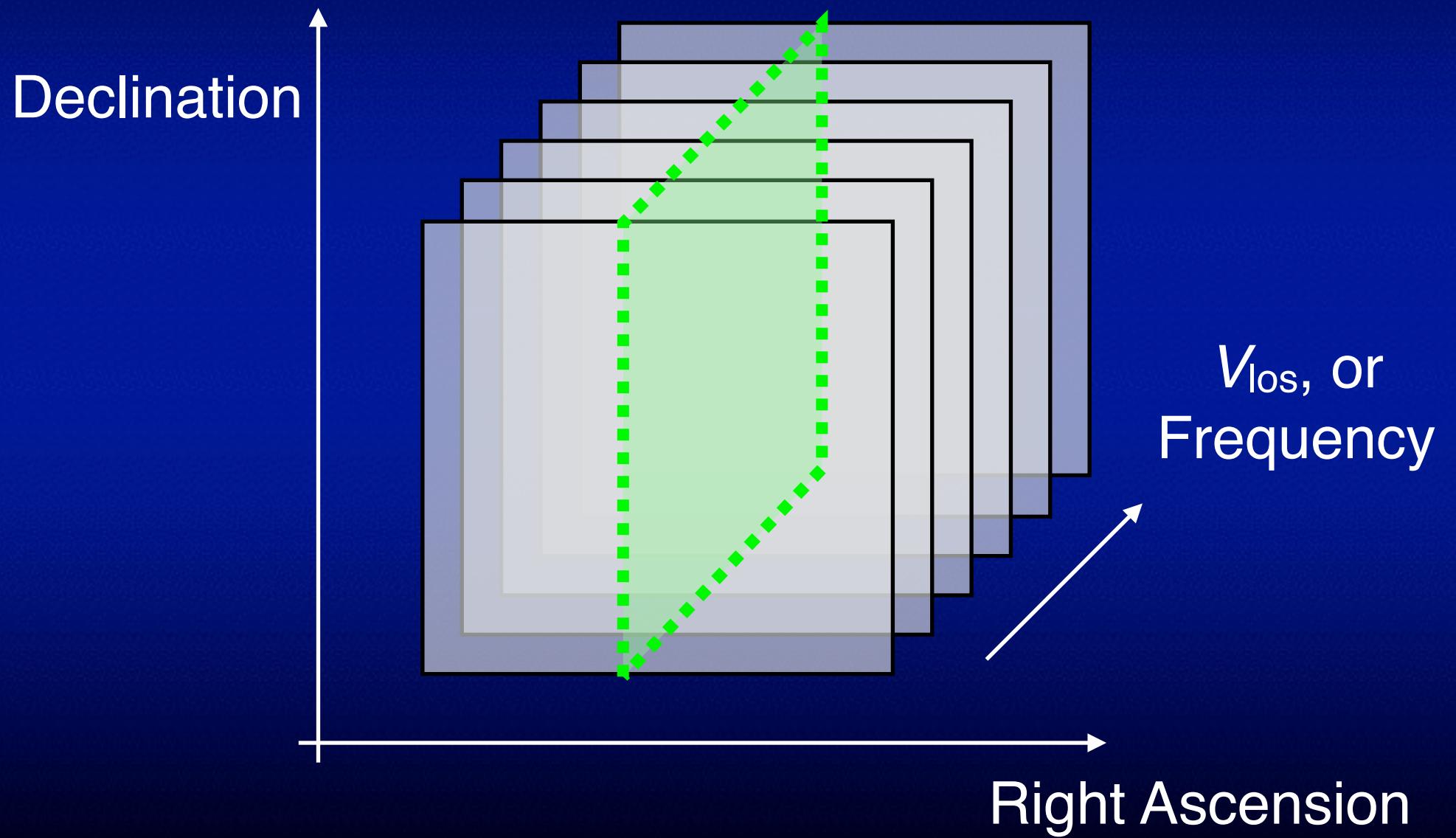
PV Diagram



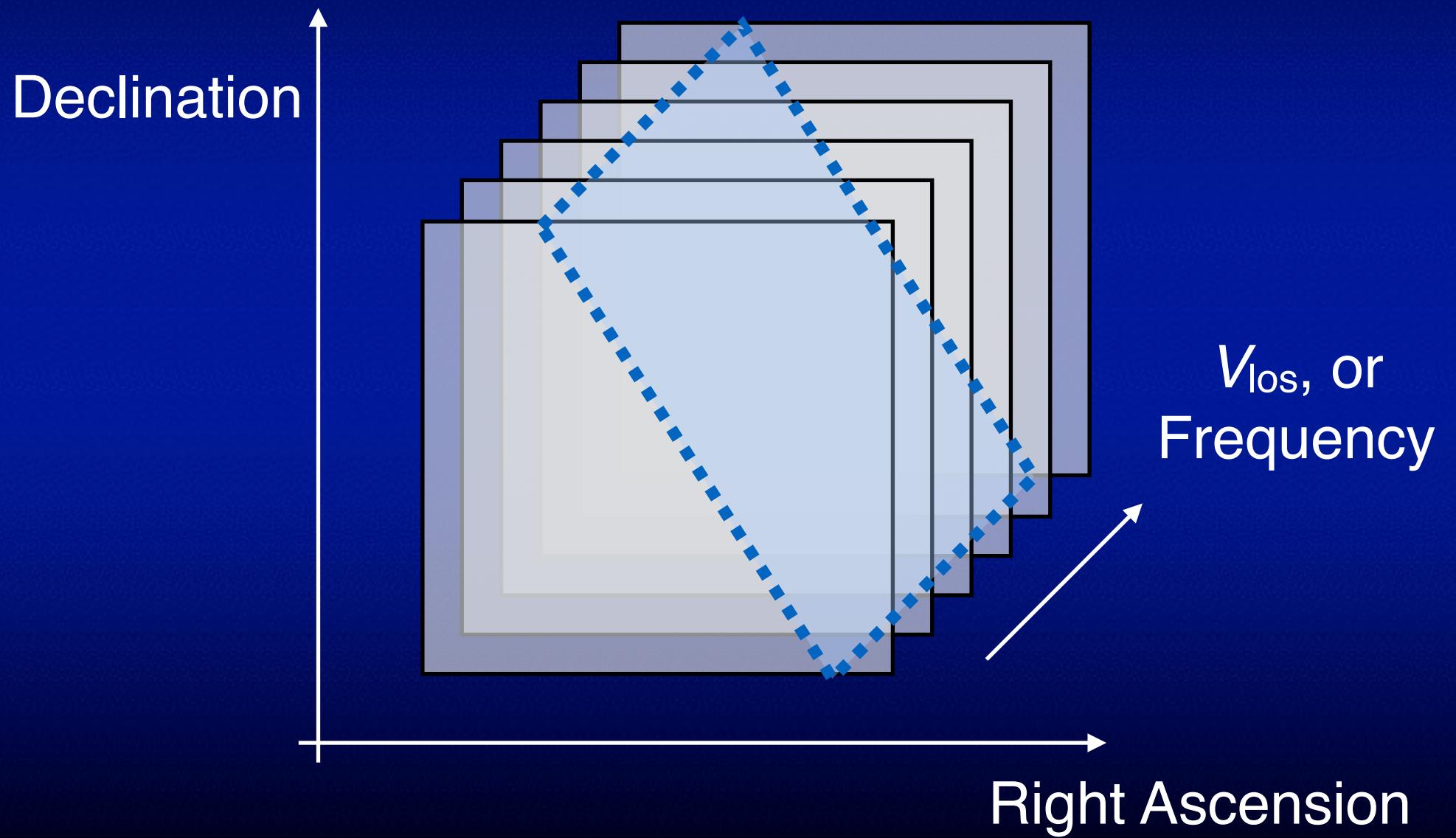
PV Diagram



PV Diagram



PV Diagram



Moment Maps

* 以下はすべて場所(a, δ)ごとで計算

$$0\text{th: } I \equiv \int T(v)dv \quad \text{積分強度}$$

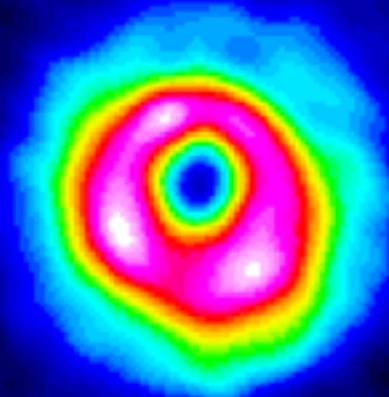
$$1\text{st: } \bar{v}_{\text{los}} \equiv \frac{\int v \cdot T(v)dv}{I} \quad \text{平均速度}$$

$$\begin{aligned} 2\text{nd: } \Delta v &\equiv \sqrt{\frac{\int (v - \bar{v}_{\text{los}})^2 \cdot T(v)dv}{I}} \quad \text{速度分散} \\ &= \sqrt{\frac{\int v^2 \cdot T(v)dv}{I}} - \bar{v}_{\text{los}}. \quad \text{局所的なもの} \\ &\quad \quad \quad \text{(乱流・熱速度)} \\ &\quad \quad \quad + \\ &\quad \quad \quad \text{ビーム内速度勾配} \end{aligned}$$

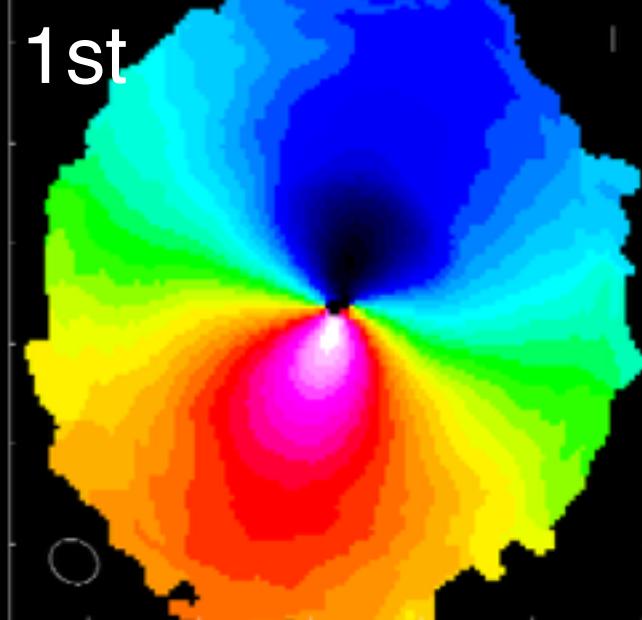
Examples: HD142527 in ^{13}CO ($J=3-2$)

Briggs Wt (upper) and Uniform Wt (lower)

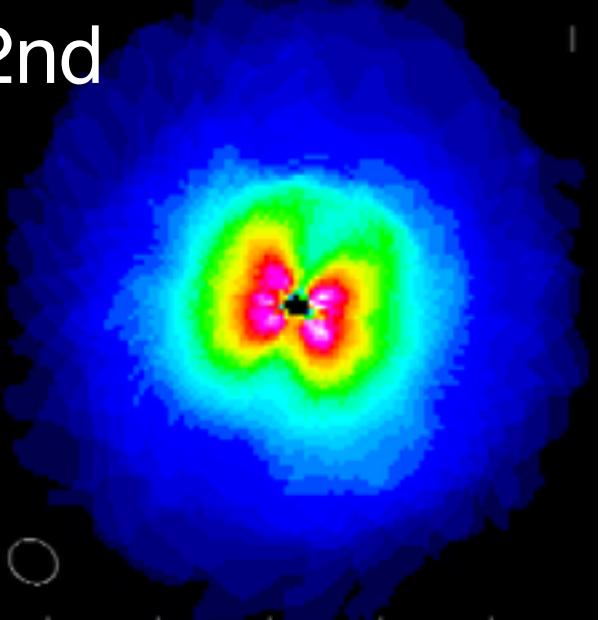
0th



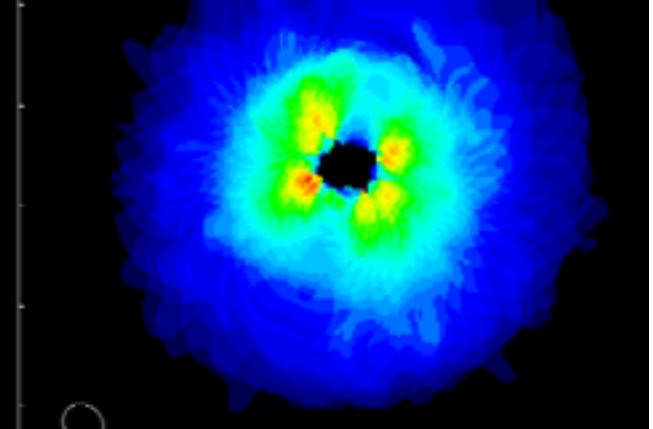
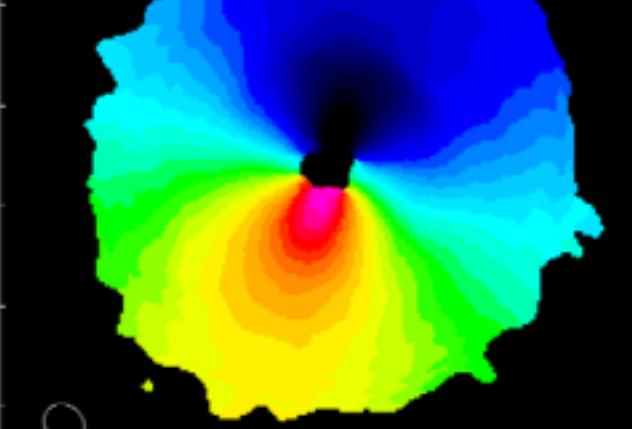
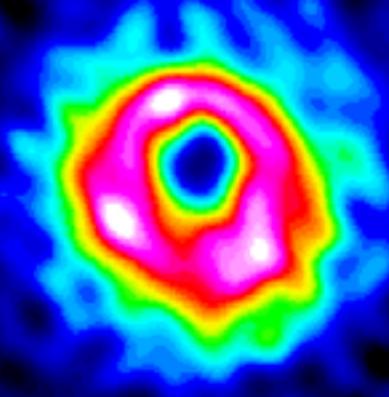
1st



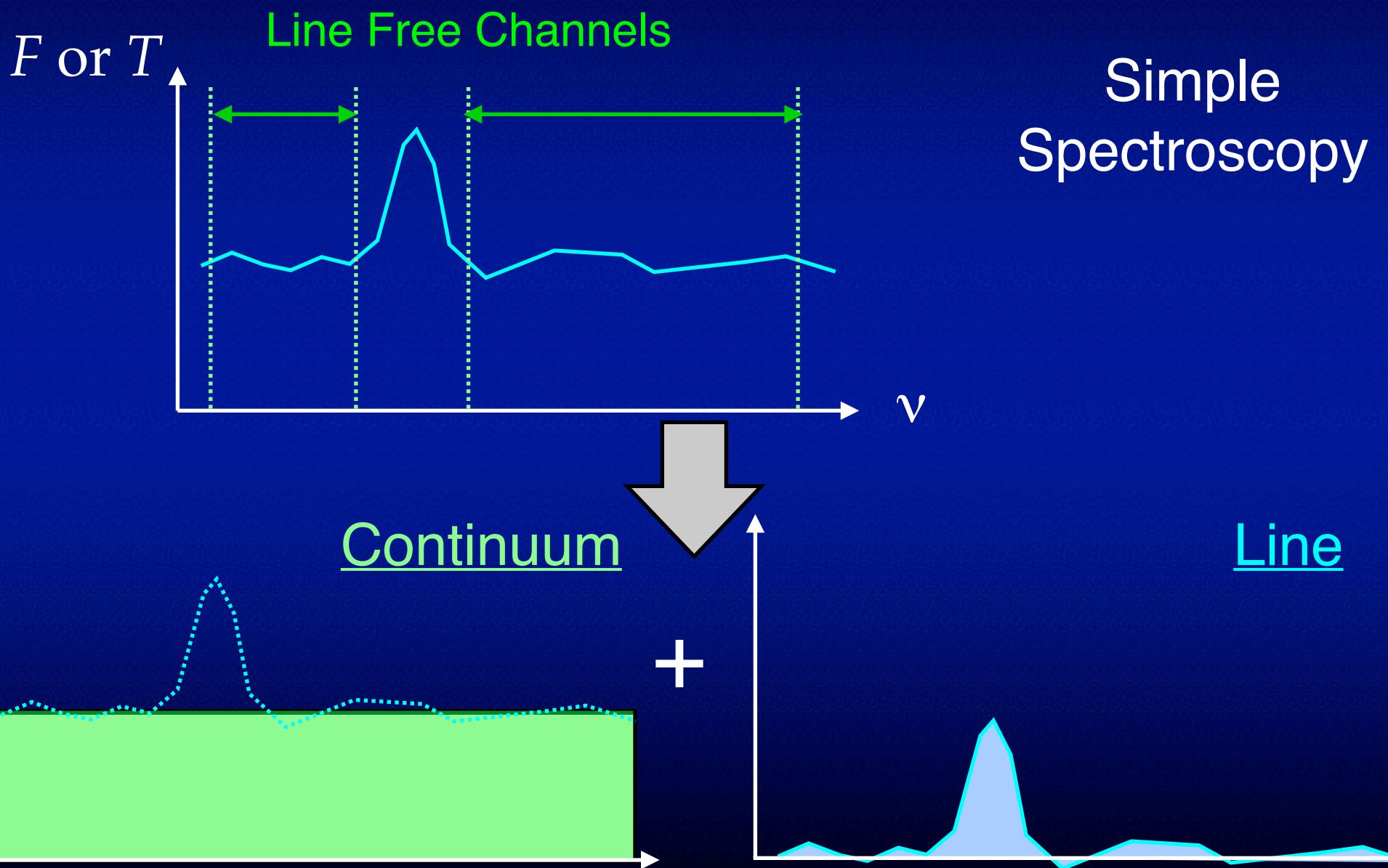
2nd



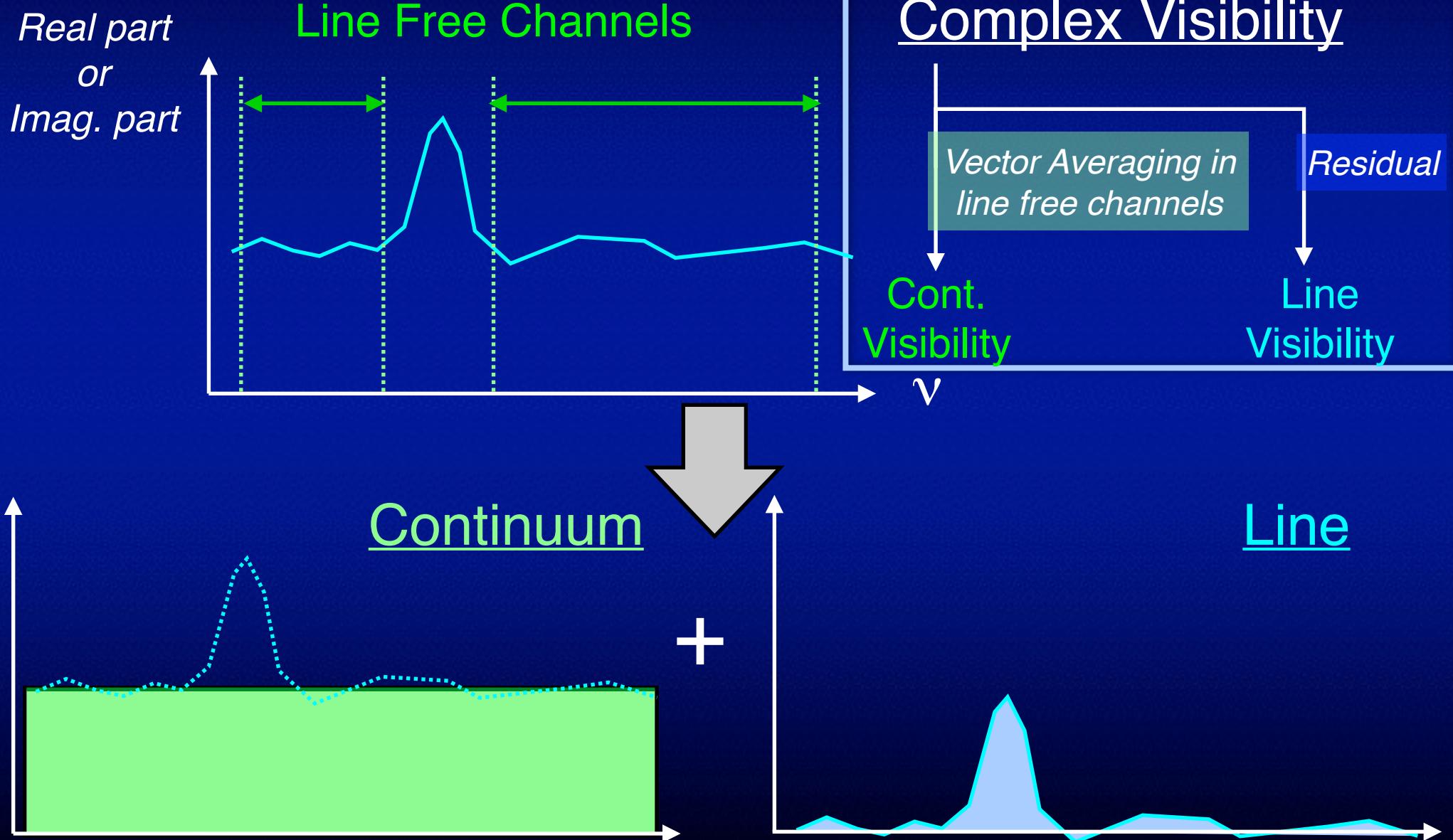
0th



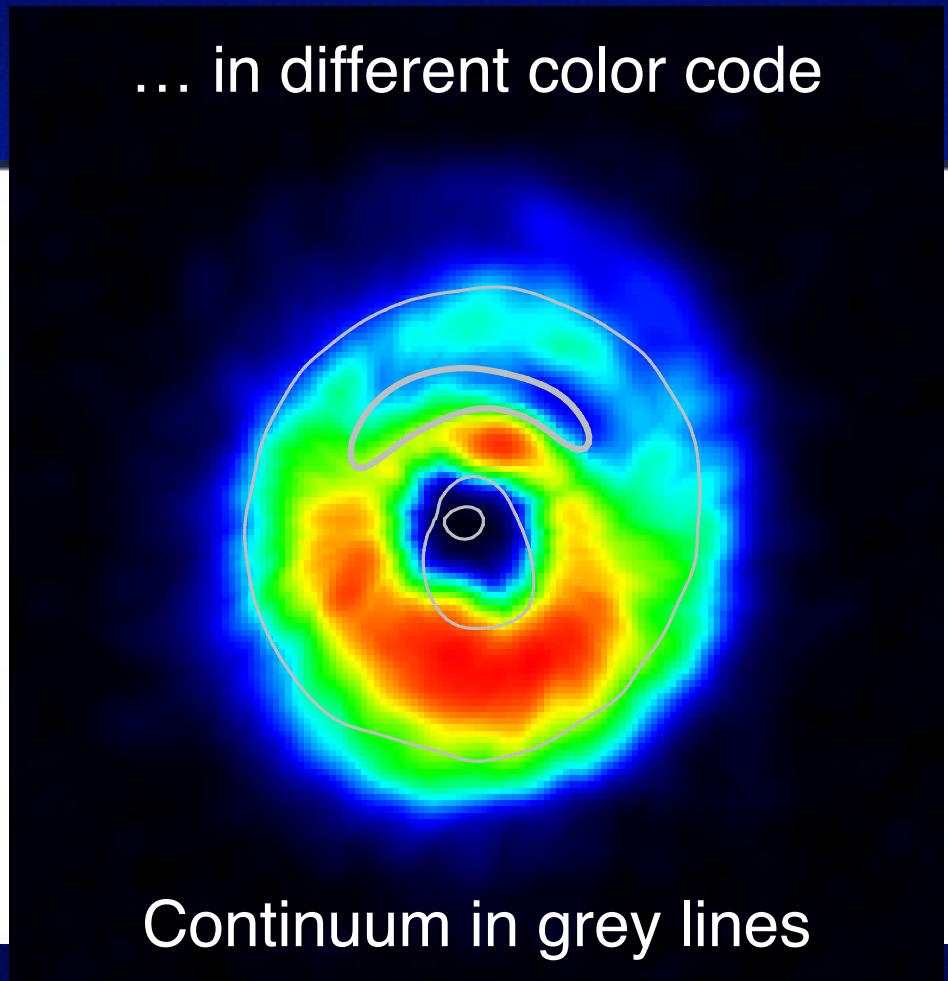
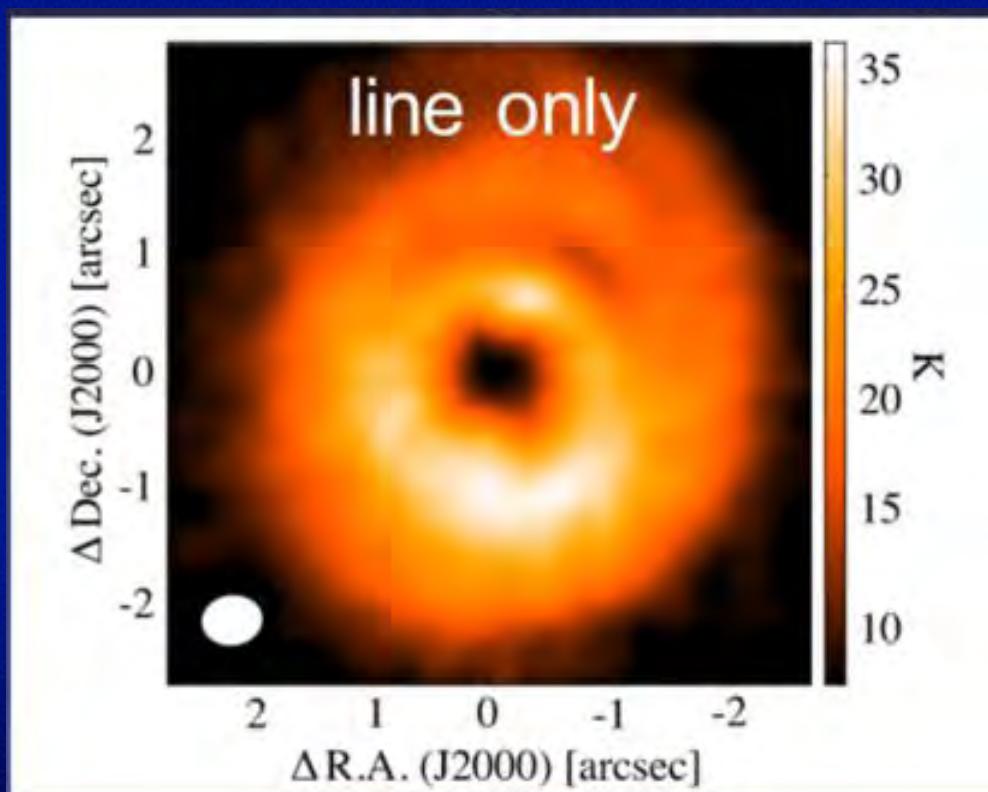
Continuum Subtraction



Continuum Subtraction

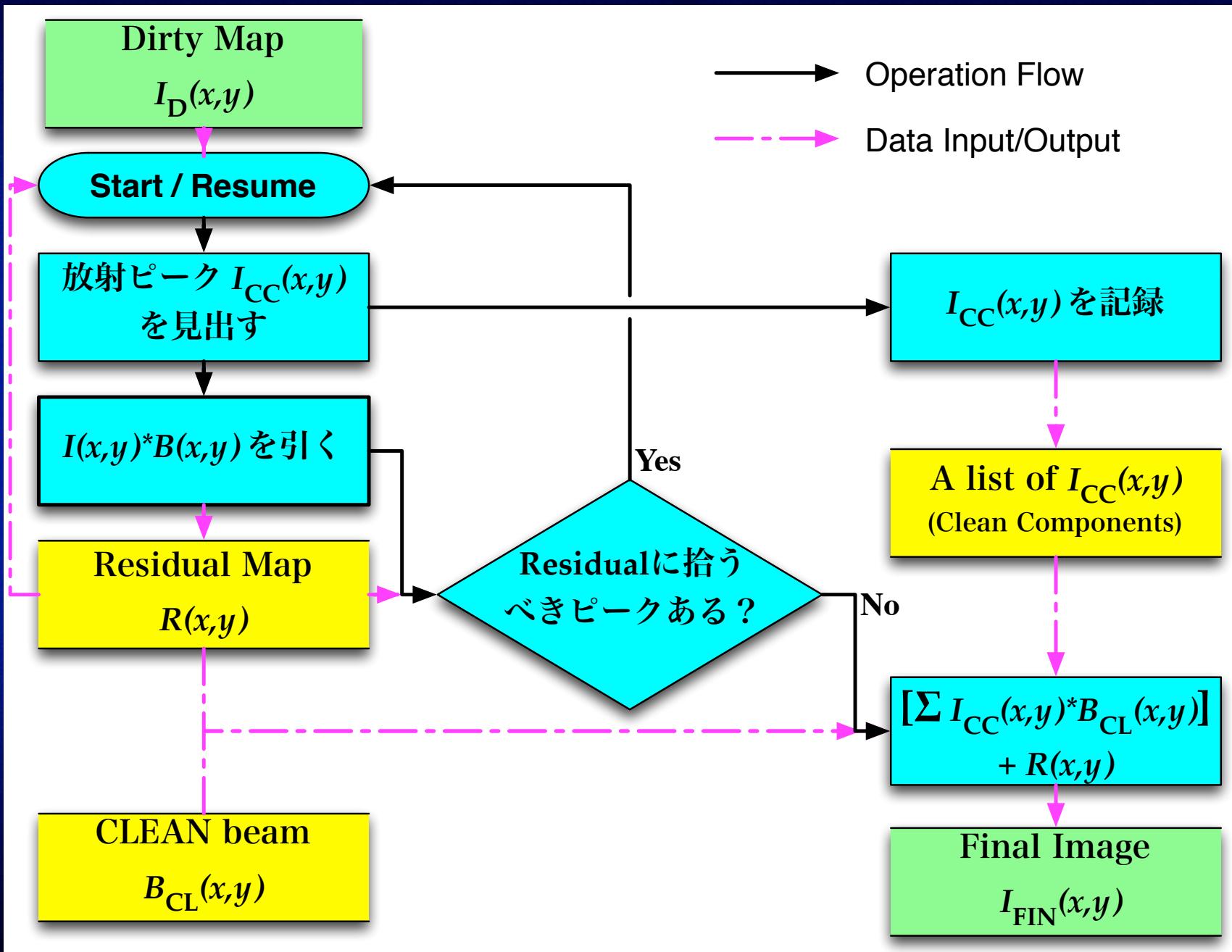


Peak T_b map of ^{13}CO ($J=3-2$) around HD142527: Line only and Cont. added

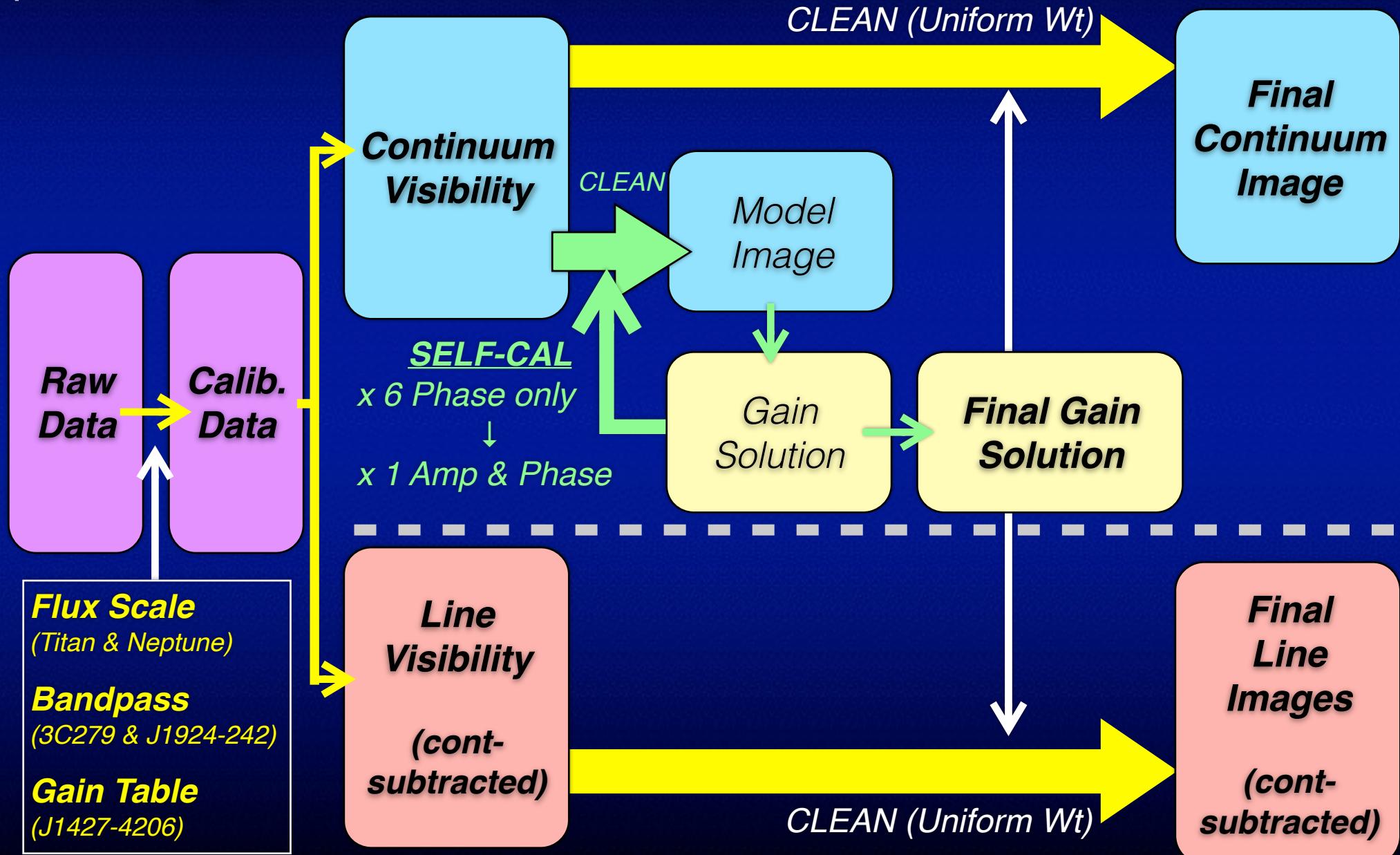


Advanced Materials

CLEAN Algorithm

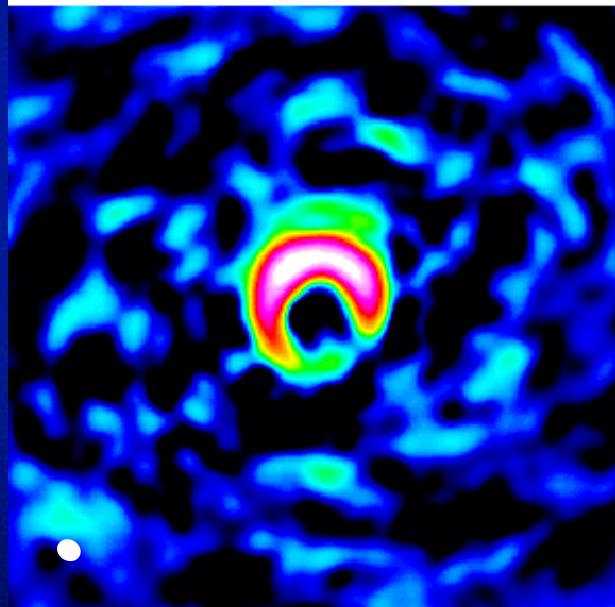


Data Reduction in the case of Fukagawa et al. (2013)

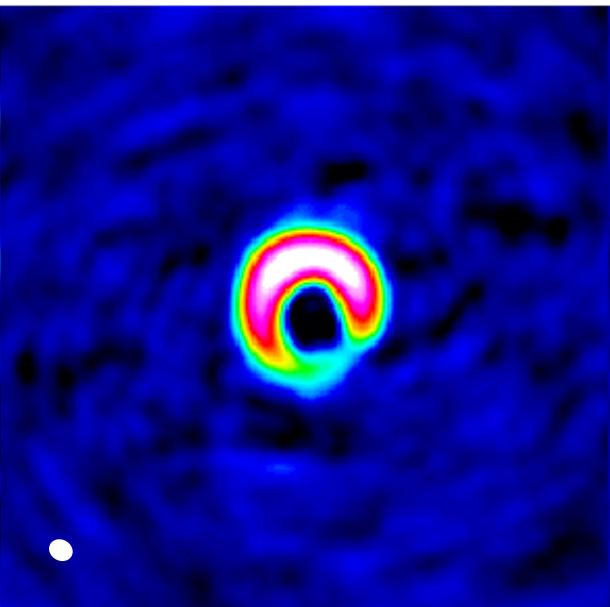


Self-Calibration: “Before-After” HD142527 Continuum @ 330 GHz

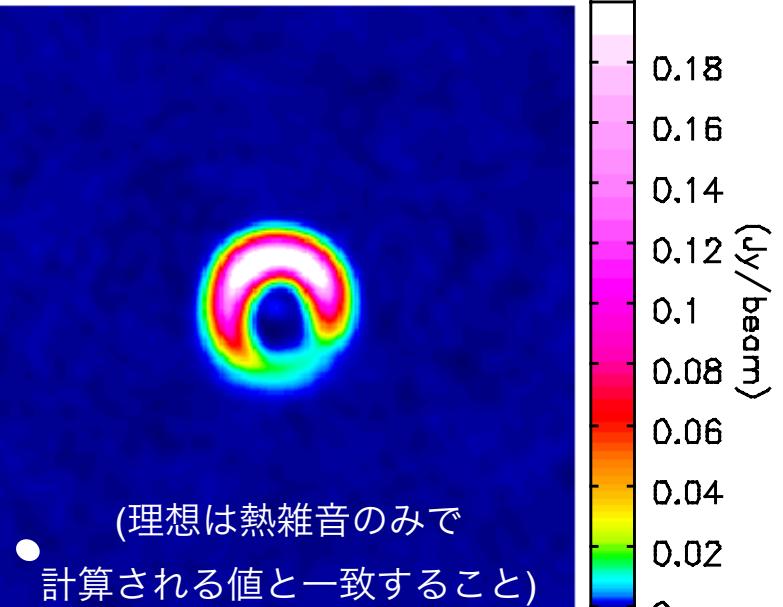
Before Self-Cal.



after
1 iteration
solving phase only



Final Image
6 iterations
solving phase +
1 iteration
solving amp. & phase



rms = 2.24 mJy/beam

0.68 mJy/beam

0.13 mJy/beam

* 少しずつ慎重に (やり過ぎると1箇所に放射を集める場合あり)

* 独立した偏波成分を取得する受信機同士でconsistentな解を示しているか

Self-Calibration

明るくコンパクト

瞬時瞬時のVisibility Phaseを
支配。予測可能。

$N_{\text{ant}} < N_{\text{baseline}}$

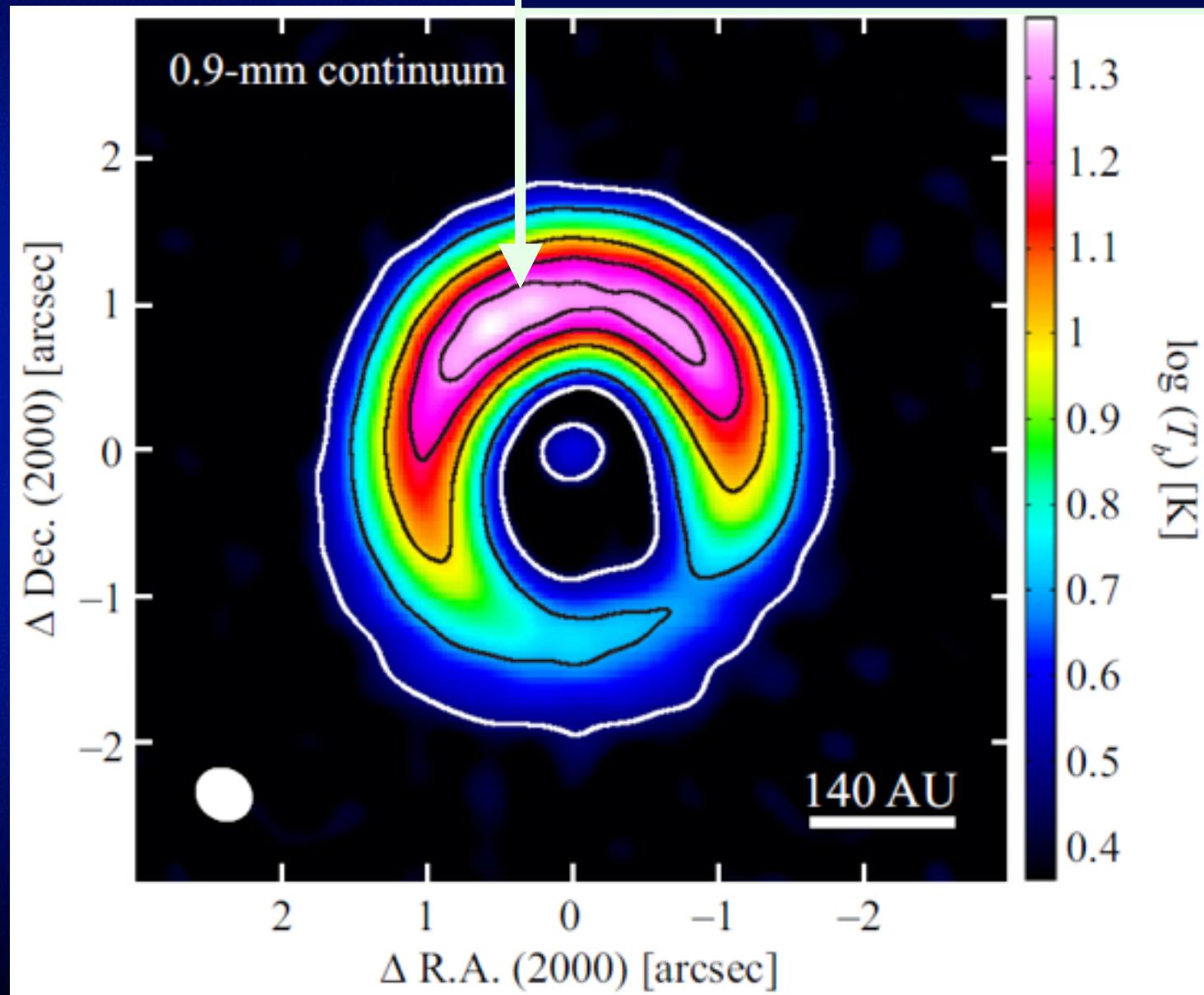


アンテナベースの
位相誤差

(大気水蒸気の揺らぎ,
装置の位相揺らぎ等)

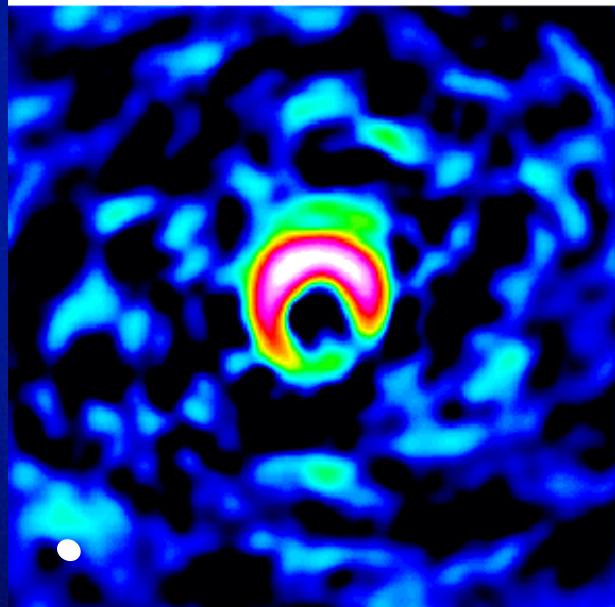
を解くことができる

(モデルイメージの
解との比較)

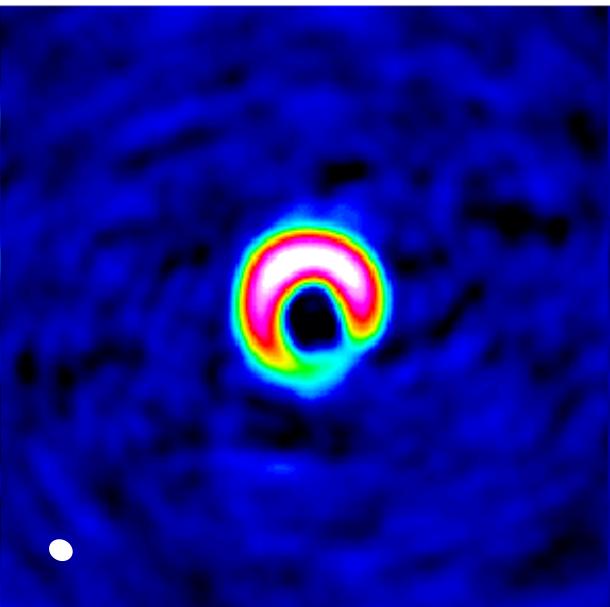


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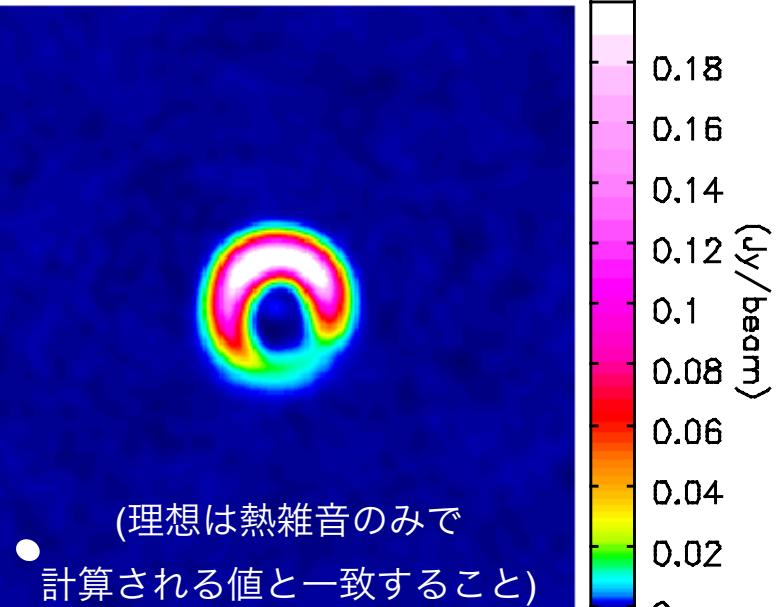
Before Self-Cal.



after
1 iteration
solving phase only



Final Image
6 iterations
solving phase +
1 iteration
solving amp. & phase



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